



# **Advanced Supercritical Fuels**

**September 20, 2011**

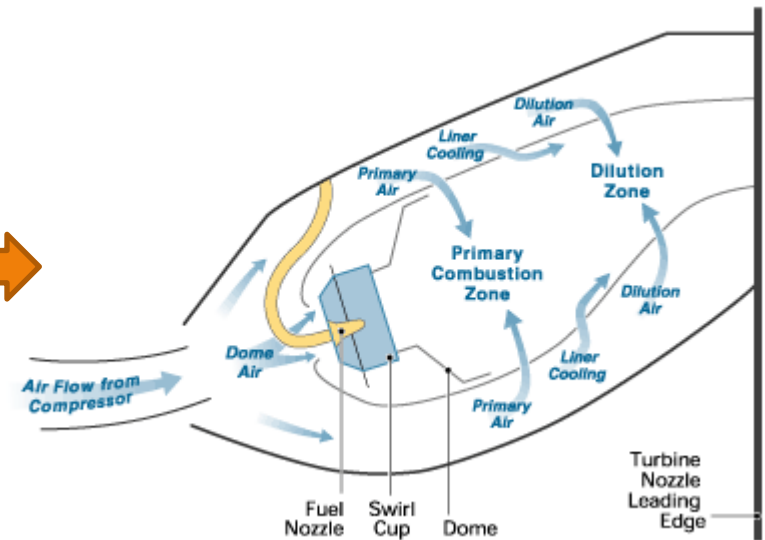
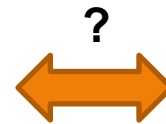
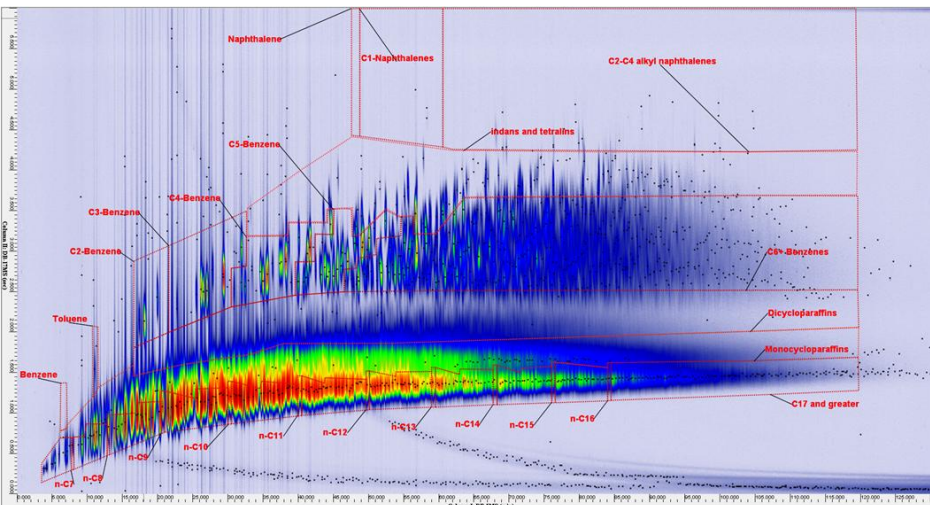
**Tim Edwards, AFRL  
Propulsion Directorate**



# What is Going On With Alternative Fuels?



- Jet fuel and combustion research being driven by alternative fuel development
- Two aspects relevant to MACCCR community:
  - Evaluation of alternative fuels with atypical compositions
  - Improvement in combustion evaluation of alternative fuels





# Alternative Fuel Evaluation (ASTM D4054, MIL-HDBK-510)



Specification Properties



Fit-For-Purpose Properties



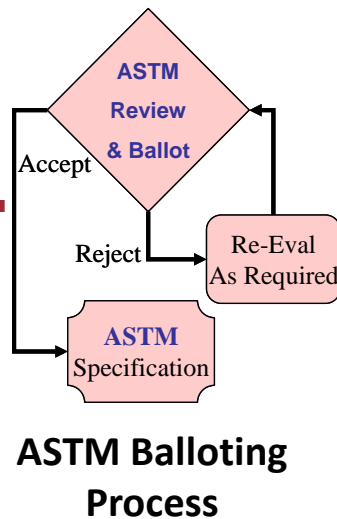
Component/Rig Testing – operability, durability



Engine/APU Testing



ASTM D7566 Revision



FAA & OEM Review & Approval

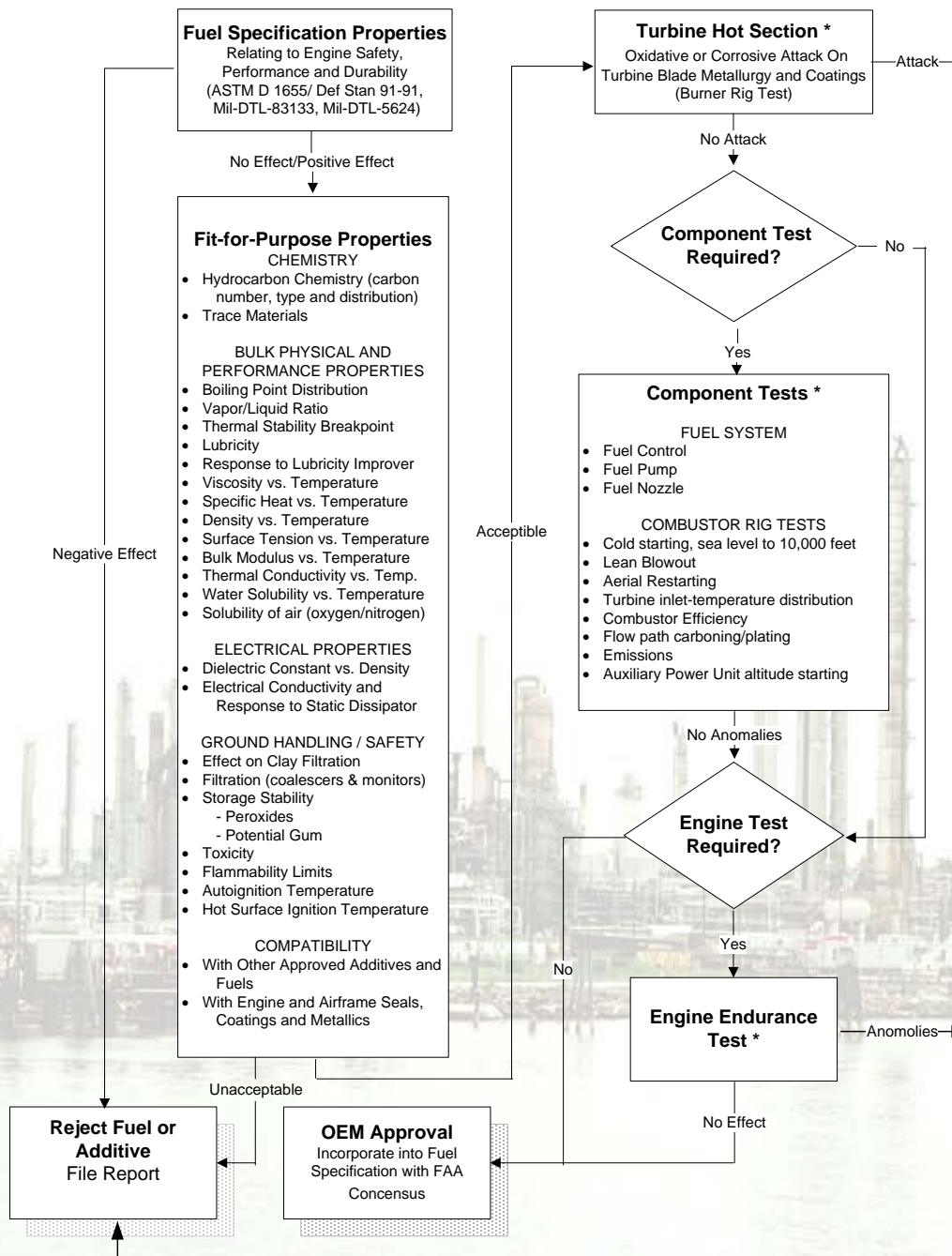


ASTM Research Report

R&D

Cert.





# ASTM Standard Practice D4054– Qualification and Approval of New Aviation Turbine Fuels and Fuel Additives

Evolving...

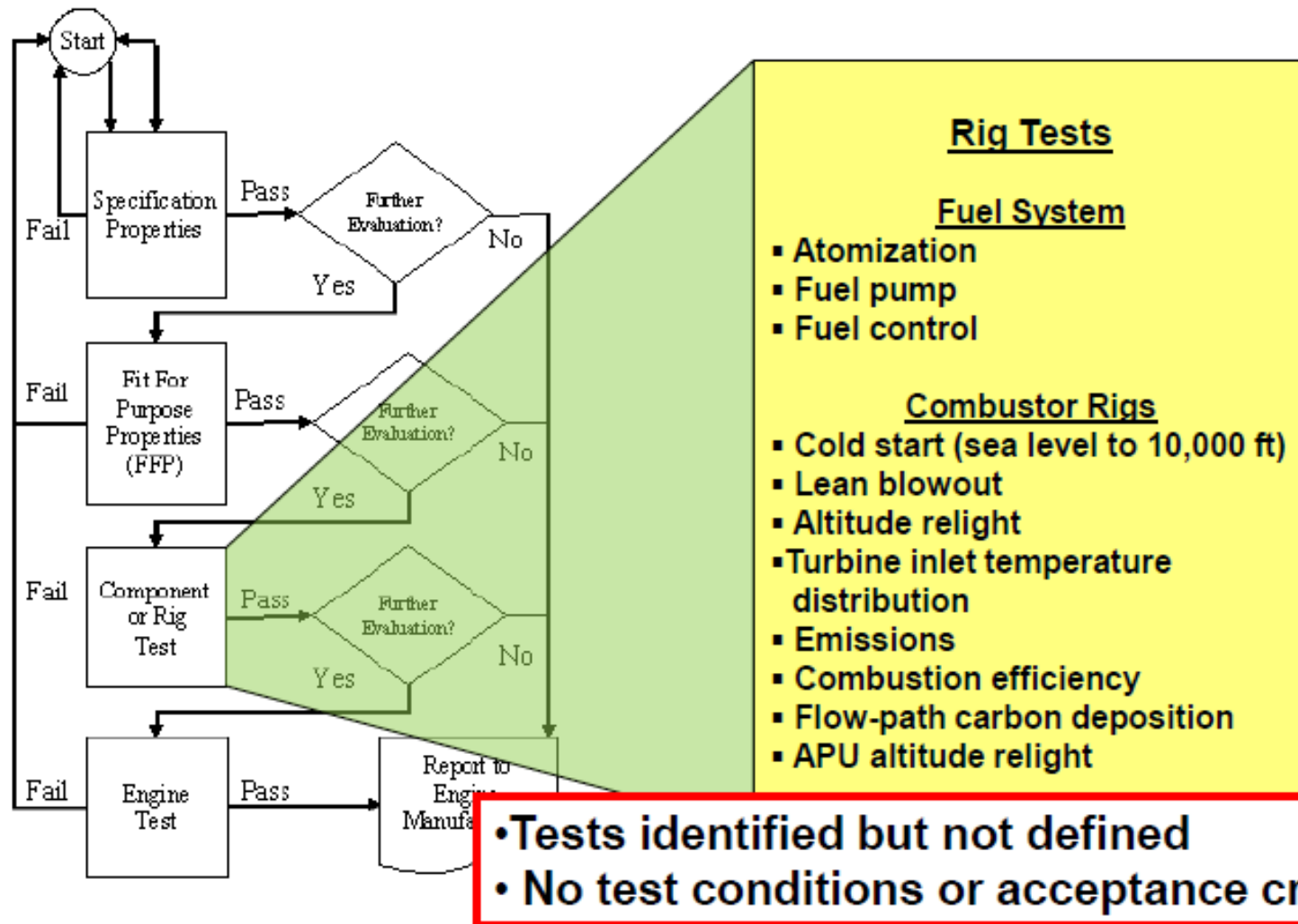
\* Testing must be performed at P&W, GEAE , RR or Honeywell due to proprietary concerns



# Combustor Operability



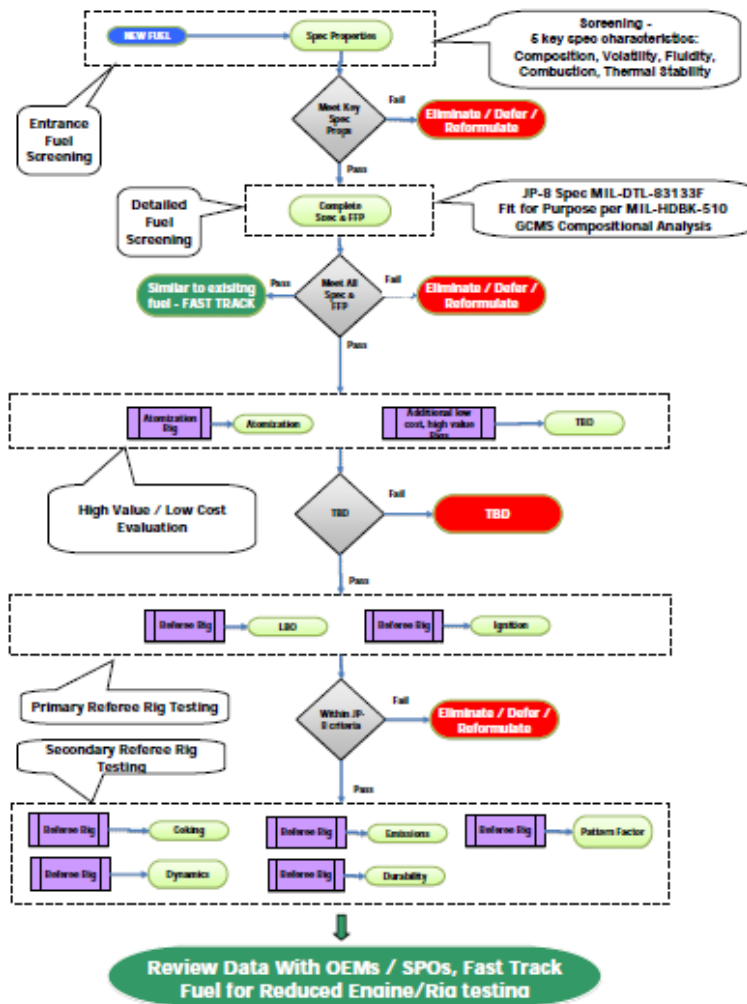
## Test Program







# OEM Proposed Combustion Rig Evaluation



◆ General Electric



◆ Honeywell



**Honeywell**

◆ Pratt & Whitney

◆ Rolls-Royce Liberty Works



**Rolls-Royce**

◆ Williams



Williams International

Testing protocol development  
requires baseline/reference fuels

- Category A – Best/worst/average JP-8/Jet A
- Category B – Current alt fuels (good/bad)
- Category C – Test fuels pushing spec limits

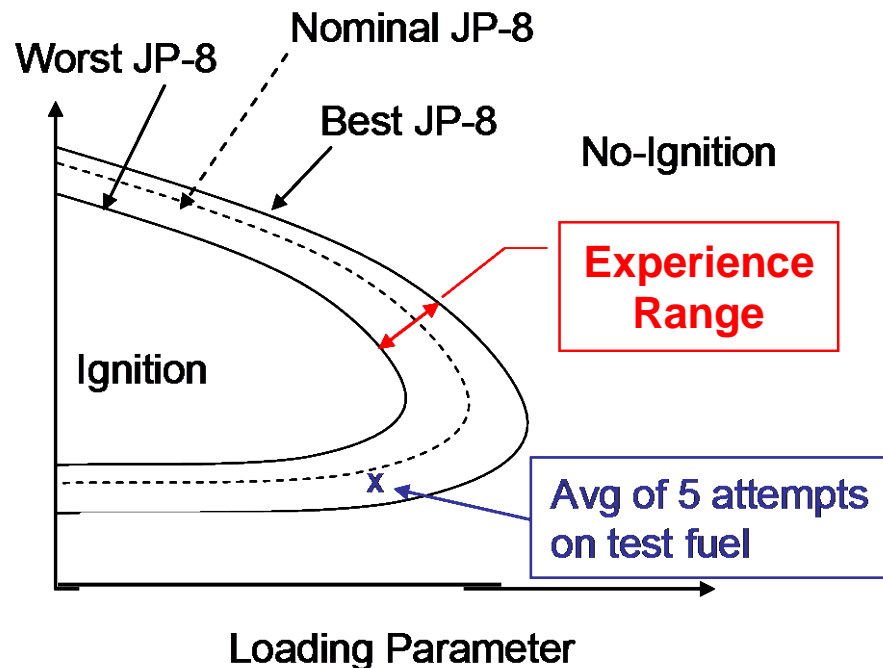
In Progress:

- Define Category C
- Volumes
- Coordinate with AFOSR combustion prog.



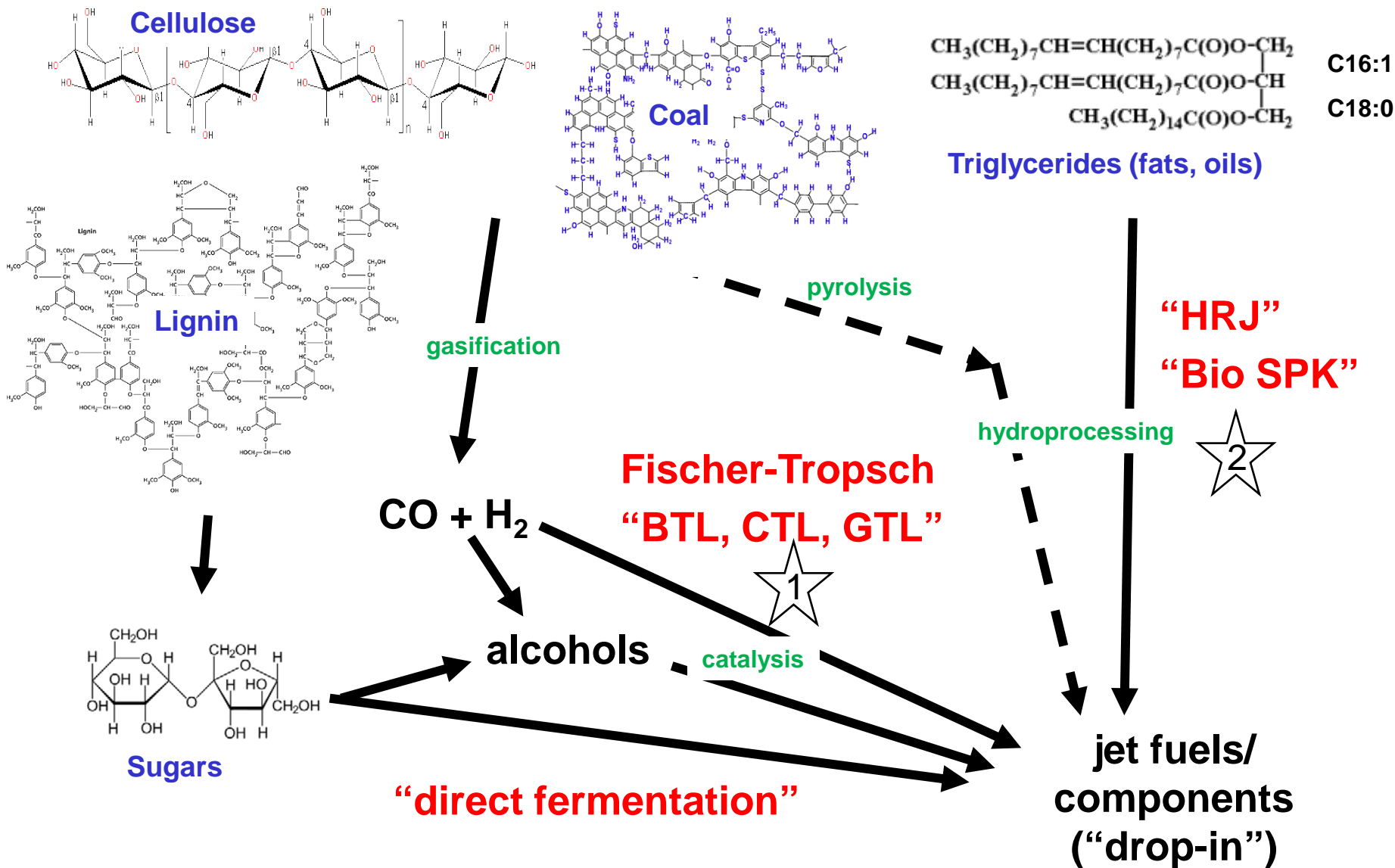
# Baseline Jet Fuels

- Best/worst jet fuel may vary with metric (cold start, LBO, relight, ...)
- Need to understand experience base with current fuels
  - In many cases, no experience with best/worst jet fuels
  - Thus, limits uncertain (what is a “fail”?)





# Alternative Jet Production Options

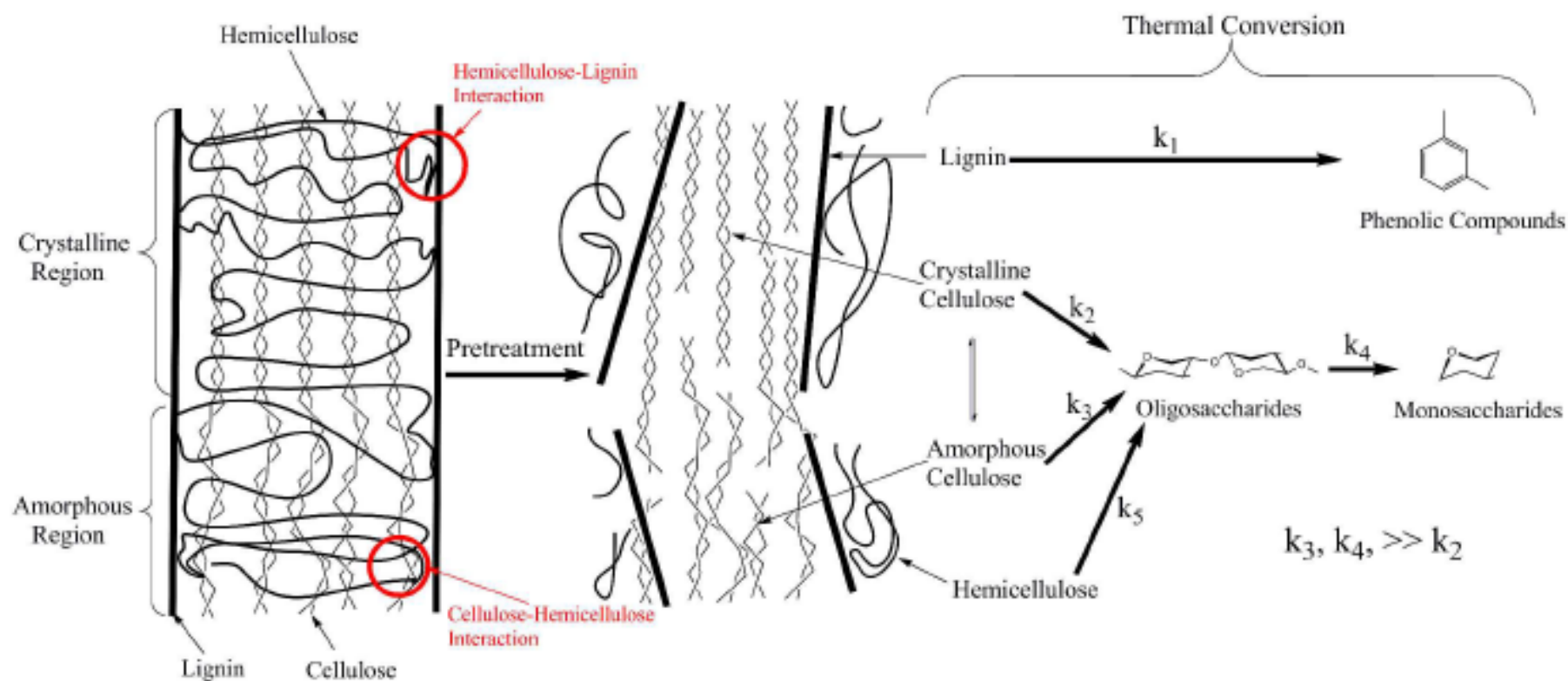






# Fuels from Woody Biomass

- Focus of DOE Biomass program
- Can yield fuels of atypical composition



## Modeling study of woody biomass: Interactions of Cellulose, Hemicellulose, and Lignin

Xiaolei Zhang, Weihong Yang, and Włodzimierz Błasiak

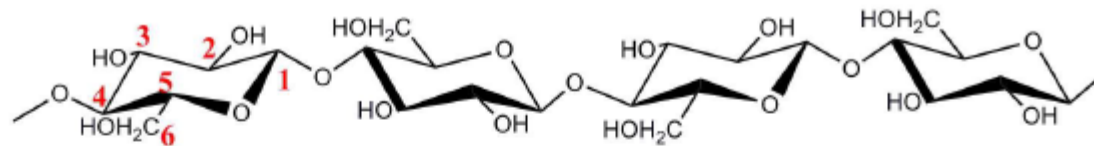
Energy Fuels, Just Accepted Manuscript • Publication Date (Web): 14 September 2011

Downloaded from <http://pubs.acs.org> on September 19, 2011



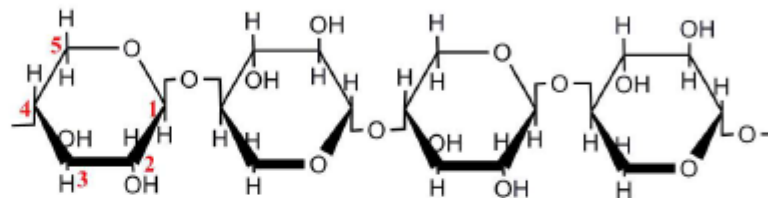
# Woody Biomass (2)

Cellulose:

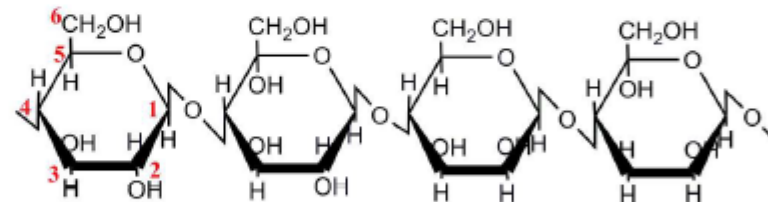


Hemicellulose

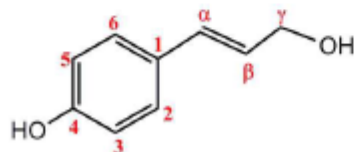
Xylan:



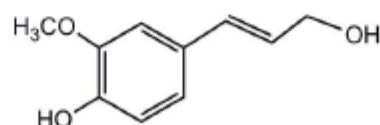
Glucomannan:



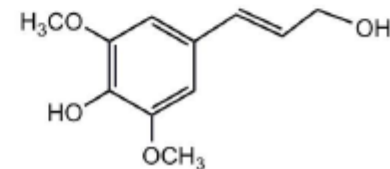
Lignin:



Paracoumaryl alcohol (H-unit)



Coniferyl alcohol (G-unit)

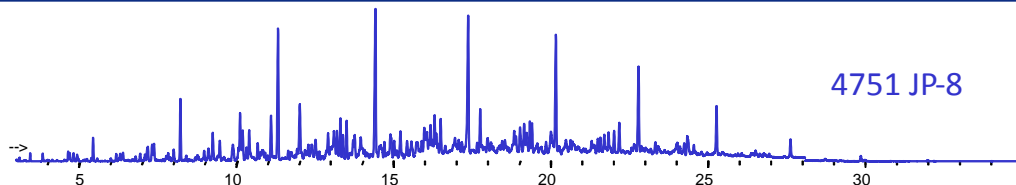


Sinapyl alcohol (S-unit)

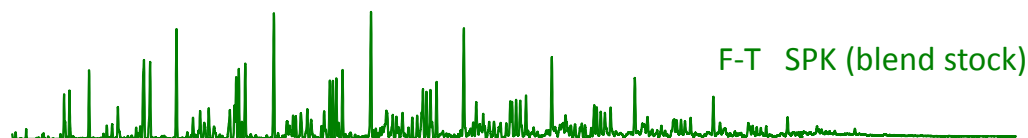


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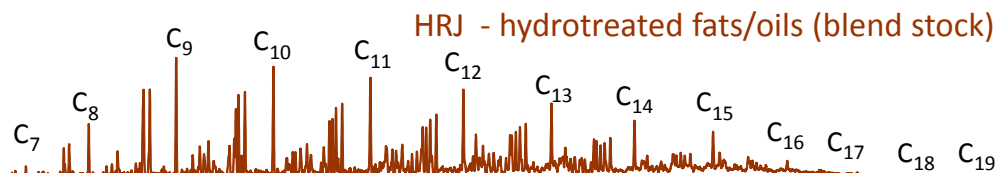
# Not All Fuels Look Like SPK.....



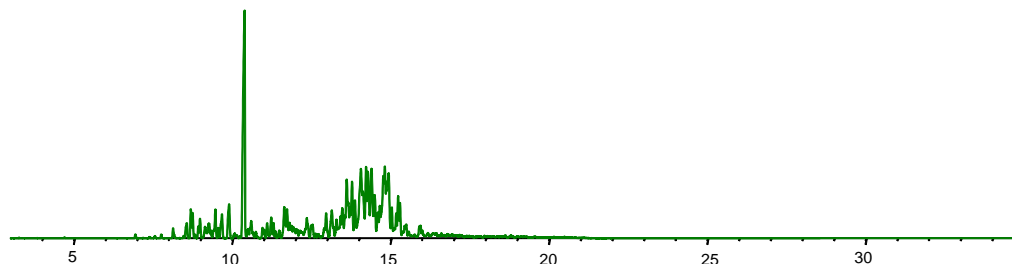
current fuels JP-8, Jet A



generic F-T SPK

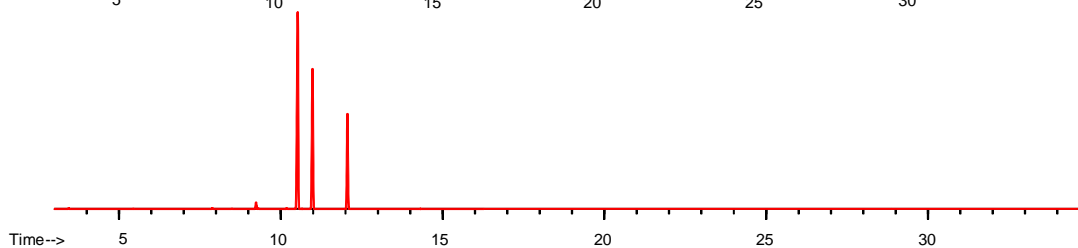


HRJ



Biofuel A

More  
Challenging!

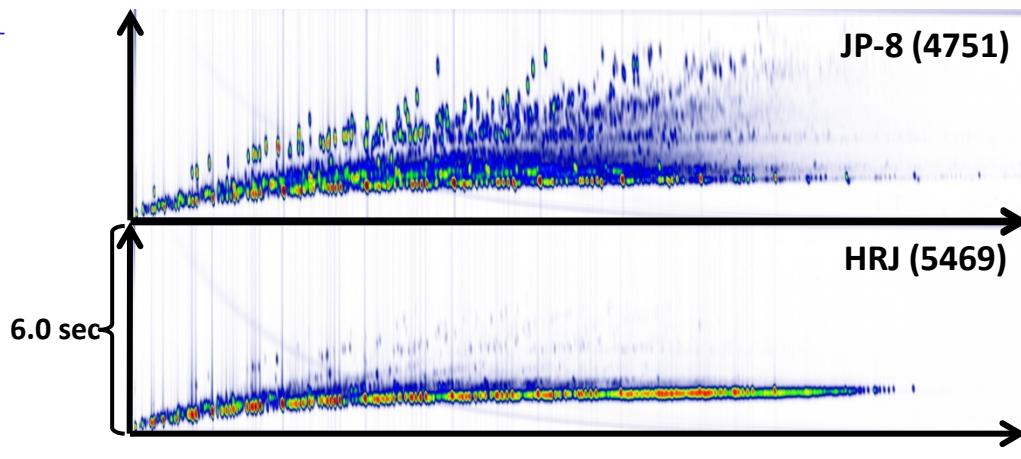
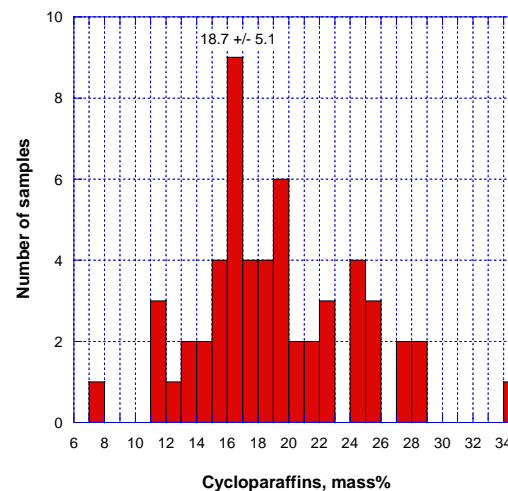
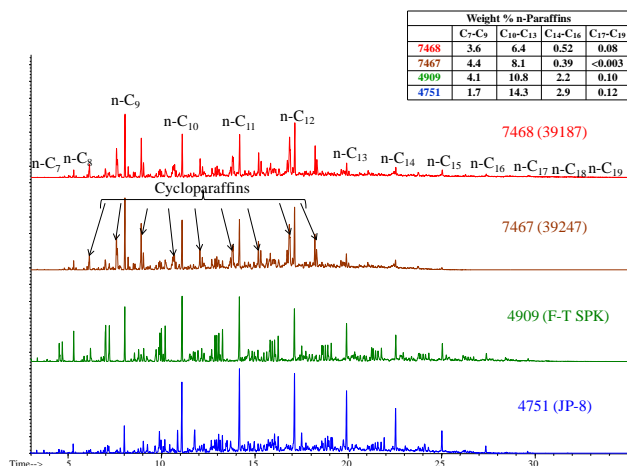


Biofuel B



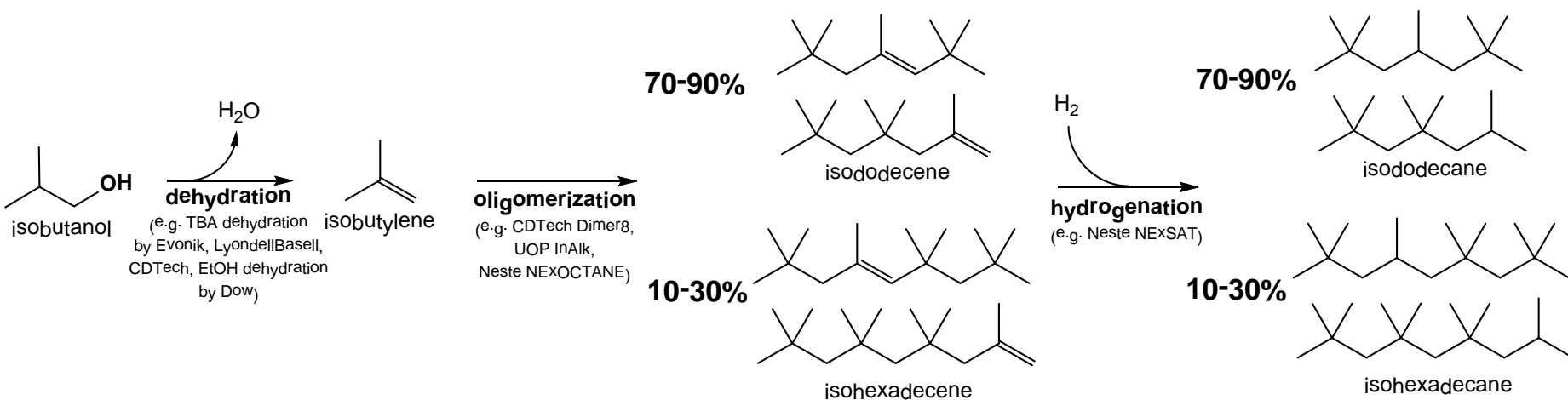
# Fuel Compositional Evaluation

- Kerosene fuel characterization by compound class req'd for alt fuel evaluation
  - ASTM D2425 (mass spec): AF/industry results led to inclusion in spec
  - GC X GC (2-D GC) holds promise for better results
  - Collaborations with SwRI, NIST, NRL, UOPC



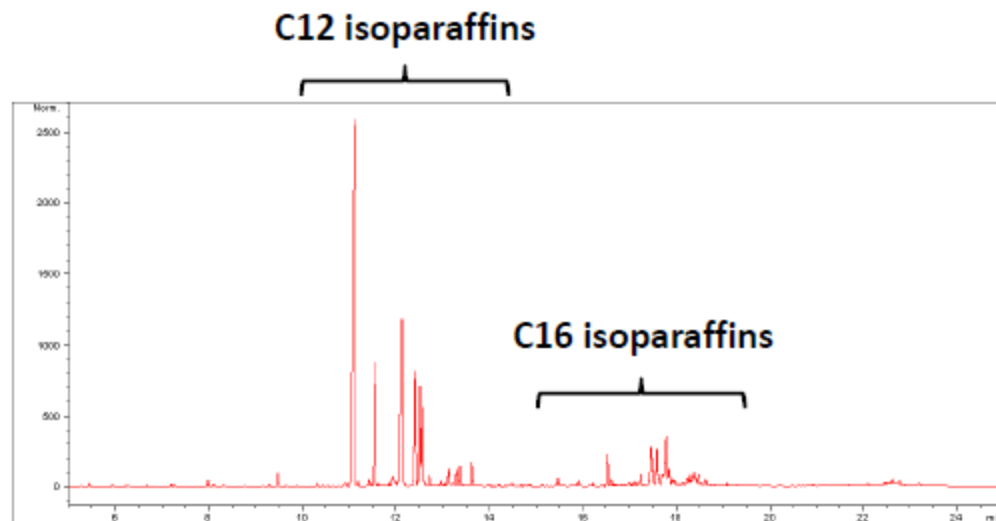


# “Alcohol to Jet”



## Hydroprocessed Synthetic Paraffinic Kerosine Derived from Fermented Alcohols

Josh Taylor, June 30, 2010 (ASTM Summer 2010 Meeting, Kansas City, MO)





# Cetane Effects

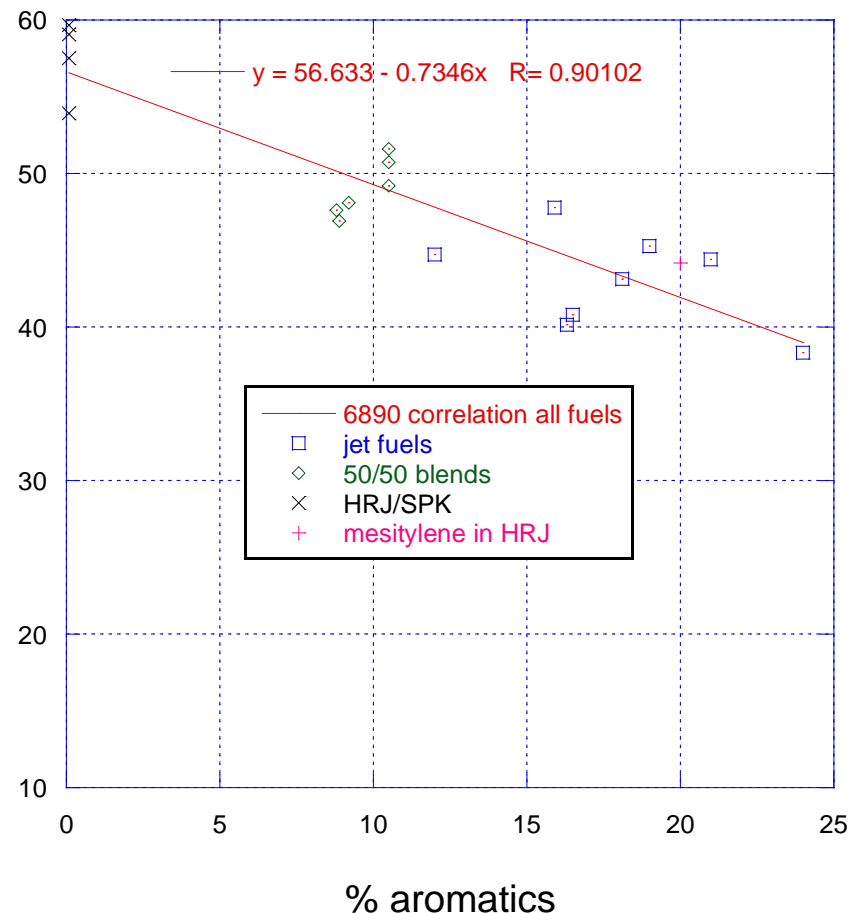
- Measured cetane relevant to gas turbine ignition or operability?
- predominantly iso-paraffinic fuels (Sasol, Gevo) have low cetane – importance?

Sasol IPK - 31



ASTM 6890 cetane

Gevo ATJ - 15





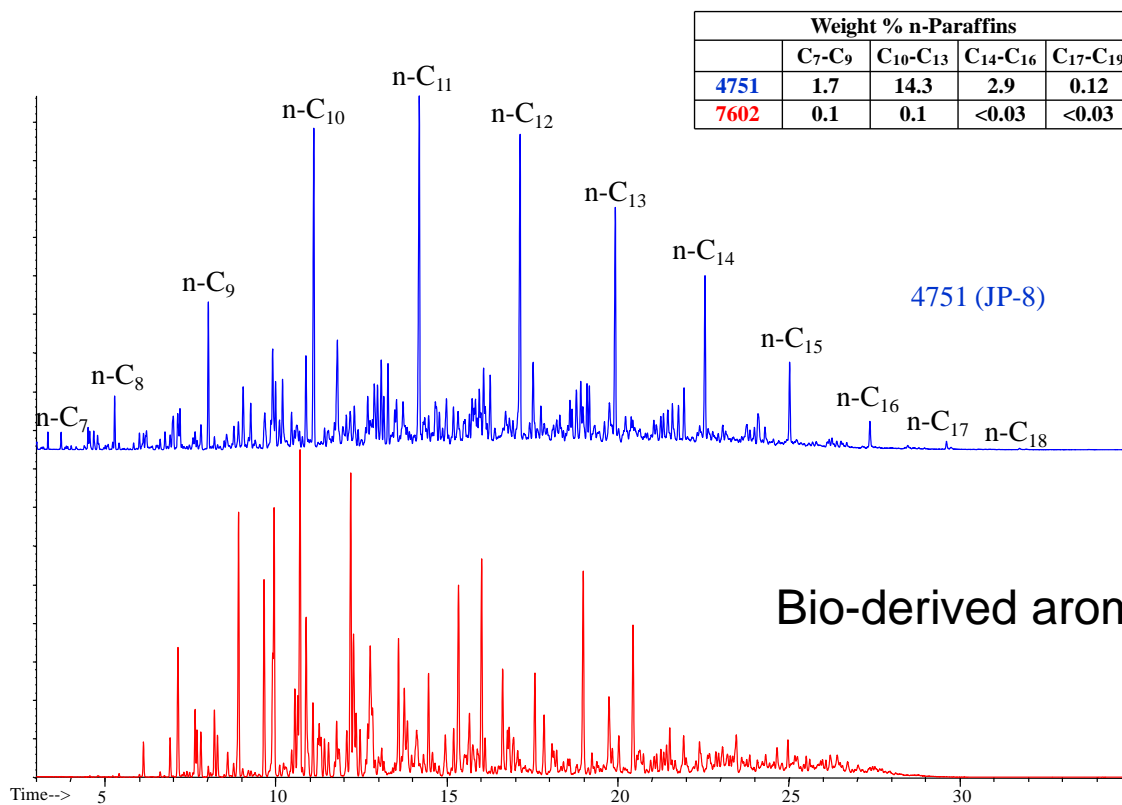


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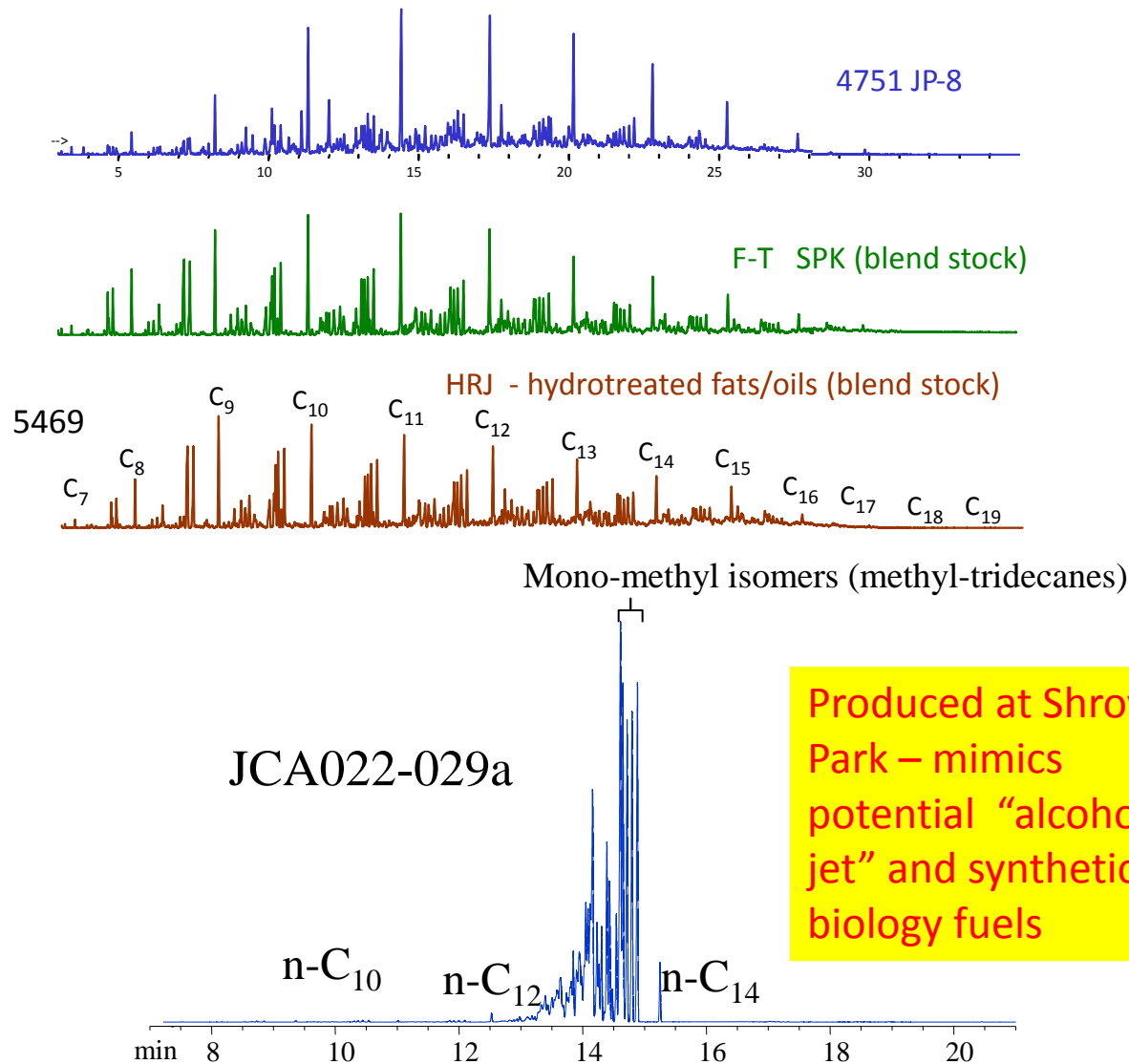
# Aromatic Blending Agents

- Blended with HRJ, SPK, or?





# Example “Worst-Case” Test Fuel





# Combustor Operability Research Questions



- **Can a fully-synthetic fuel (vs a 50/50 blend) be certified for aircraft use?**
- **Is a minimum boiling range requirement necessary for combustor/augmentor operability?**
- **Are fuels with 2-3 hydrocarbons acceptable?**
- **For wide-boiling fuels, is there a problem with differing distributions of species (e.g., aromatics)?**
- **Is measured cetane number relevant to gas turbine engine operation?**



# Summary



- **Combustion evaluation of alternative aviation fuels is the “long pole in the tent” at the moment**
- **Key role for MACCCR community is supplying basic research support to this effort**
- **DOD funding picture is looking fairly grim....**